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## Paper No. 8: The ADAGE Nesting and Drawing System

U.S. DEPARTMENT OF THE NAVY
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**R**esearch and
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# THE ADAGE NESTING AND DRAWING SYSTEM

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## 1. INTRODUCTION

The ADAGE Interactive Nesting and Drawing System is based on the ADAGE GS/300 Interactive Graphics System and a main host computer. The main computer contains the ship design routines, such as AUTOKON, and the Graphics Display System is used to display individual parts calculated by AUTOKON or to *draw* new parts as may be required, to visually nest these parts on a sheet meal plate, then to display the tool path required to cut the nested parts layout.

This Nesting and Drawing package was first developed two years ago as a feasibility study by ADAGE, s. p. a. in Italy for a major Italian shipyard, Italcantieri, s. p. a. Since that time Italcantieri has completed the development to the point that it is scheduled to go into production in July, 1976.

The Italcantieri equipment configuration is an:

ADAGE GS/340 with
32-K of 30-bits/word core memory
*2*- 81- million bit disk drives
1- electrostatic printer plotter
2- 23" round CRT display consoles,

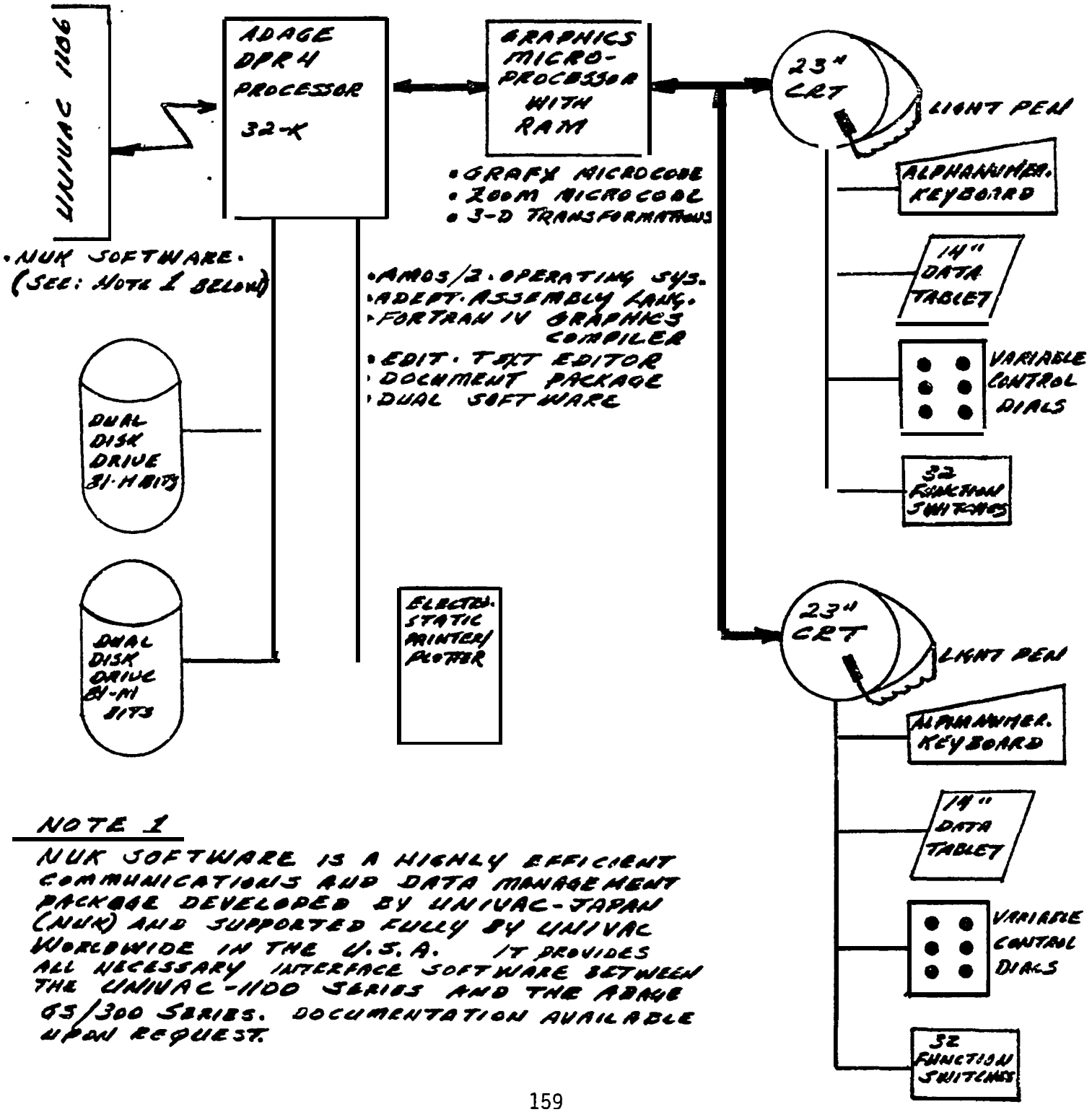
each with:

- Alphanumeric Keyboard
- 32 Function switches
- 11″ Data Tablet
- Variable Control Dials (6)
- Light Pen (not used)
- Hardware Window
- Circle Generator
- Dynamic Zoom (l28:l)

All running remote (3 km. ) to all UNIVAC 1106 multiprocessor via a 5O-K baud line. (See Figure A)

The software as described herein and in the Software Specification is available from ADAGEI or Italcantieri,

# SYSTEM CONFIGURATION ADAGE GS/340 DUAL CONSOLE AT ITALCANTIERI




## NOTE 1

NUK SOFTWARE IS A HIGHLY EFFICIENT COMMUNICATIONS AND DATA MANAGEMENT PACKAGE DEVELOPED BY UNIVAC-JAPAN (NUK) AND SUPPORTED FULLY BY UNIVAC WORLDWIDE IN THE U.S.A. IT PROVIDES ALL NECESSARY INTERFACE SOFTWARE BETWEEN THE UNIVAC-1100 SERIES AND THE ADAGE GS/300 SERIES. DOCUMENTATION AVAILABLE UPON REQUEST.



FIGURE-A

## II. DRAWING MODE

This mode allows the operator to draw new parts to be stored or nested. The operator has at his disposal

- A Display Screen (CRT)
- Digital Data Tablet
- Variable Control Dials
- 32 Lighted Function Switches
- 2 Foot Pedals

He also has a constantly up-dated list of geometric parameters displayed on the bottom of the screen. These are, as they appear:

| | |
|---|---|
| DELTA X | X |
| DELTA Y | Y |
| REL. ANG. | ABS. ANG. |
| DISTANCE | DETAIL |
| | GRID STEP |

Where

DELTA X — Increment, along the X-axis, of the current vector with respect to the end point of the previous vector.

DELTA Y — Increment, along the Y-axis, of the current vector with respect to the end point of the previoUS vector.

REL. ANG. — Angle included between the current vector and the previous one.

DISTANCE — Length of current vector.

*X* — Distance along X-axis of the moving end of current vector with respect to the specified origin.

*Y* — Distance along Y-axis of the moving end of the current vector with respect to the specified origin.

ABS. ANG. — Angle included between the current vector and the X-axis unrotated)

DETAIL — Maximum precision used.

GRID STEP — Step value of the reference grid when it is displayed.

The range of values of the coordinates displayed on the screen are a direct function of the steel sheet to be worked. At the present time it is possible to specify a steel sheet with dimensions of 16.350 meters x 16.350 meters (53. 1 ft. x 53.1 ft. ) and keep an overall precision of 1.0 mm. (0. 039 in. ) Larger sheets can be dealt with, but at a loss of precision. For example, sheets with dimensions between 16.350 meters (53. 1 ft. ) and 32.7 meters (lo6. 2 ft. ) can be handled but with a precision of only 2 mm. (O. 078 in. ) which is about 5/64 of an inch.

The above values change in meaning as the user changes operations. For example, by placing the stylus in contact with the data tablet a cross is displayed on the screen. The cross moves correspondingly with the stylus until the cross is in the desired position. By depressing the tip-switch a point is selected. If the stylus is then moved to a new point, the values in DELTAX and DELTAY contain the incremental values of X and Y from the previous point and the values in X and Y contain absolute values of X and Y with reference to a specified origin, such as the lower Ieft-hand corner of the steel plate. DELTAX and DELTAY can also be used as the center of a circle while the DiSTANCE value can be used as the radius. At times, it may be difficult to position the stylus and obtain an exact desired numerical value displayed on the screen. In this case the operator can press a function switch (9 - 12) to select the fine tuning function which allows him to scale the movement of the stylus so that one inch of movement of the stylus will produce 0. 1 inch of movement on the screen. The scale values selectable range from 5 to 1000. Therefore, any particular numerical value within range can be exactly obtained.

The attached Software Specification describes the geometric entities available and a Software Operating Instruction Manual is available from ADAGE.

## III. NESTING MODE

A list of parts to be nested can be called from storage on the main computer and stored on ADAGE disk storage. This can be done periodically so that many parts are called at once - the ADAGE GS/300 then runs stand-alone until a completed cutter path or group of them are ready to be transmitted back to the main computer for storage or processing. Individual parts may now be called up on the screen. These can be parts previously drawn using the CRT or those created directly by the AUTOKON package. These parts are then automatically scaled to correspond to the scale of the sheet of metal being displayed. Each part, or a group of parts, can then be transIated in X and Y using variable control dials A and B and rotated around the Z-axis by turning variable control dial C. They can be rotated around the center of gravity or any selected point. There are various functional operators in the system to make the operators task easier, for example, selecting one edge of the plate and a straight line edge of a part will cause that part to position along the edge of the plate. Or parts with two straight edges may positioned adjacent and parallel, offset by the cutting torch diameter (A variable system parameter). Throughout the Nesting operation a value is displayed which indicates the percent of the sheet metal being used.

In the Nesting mode up to eight sheets of metal of different sizes and differently oriented may be stacked up, so that the parts being nested at that time will appear on all sheets displayed at that time.

The full capabilities of the Nesting Mode, including:

- Part storage and retreival
- Parts set-up
- Nesting completion, and
- Nesting storage and retreival

are discussed in detail in the attached Nesting Software Product Specification.

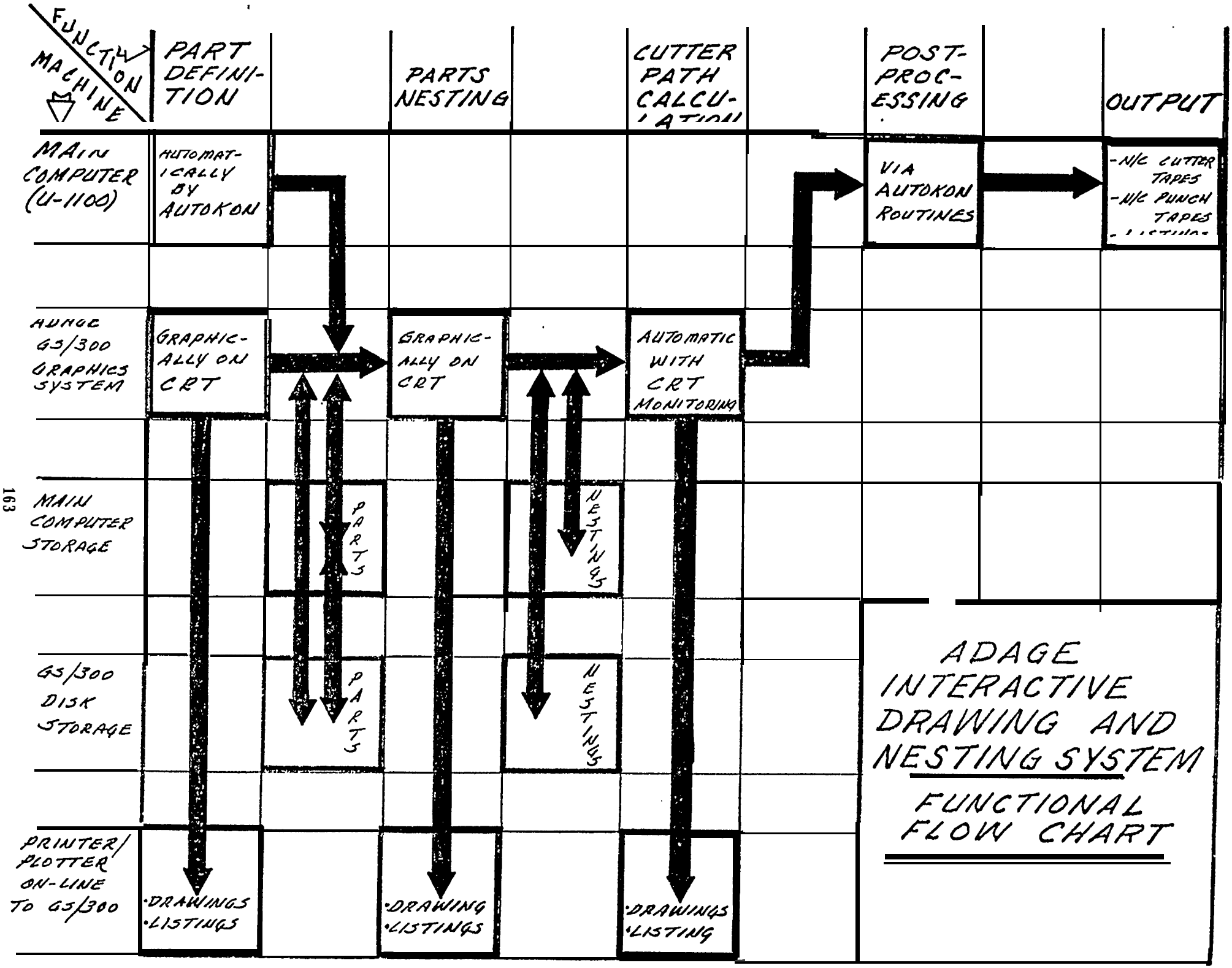
## IV. CUTTER PATH CALCULATION MODE

Once a Nesting is completed, or hopefully completed, the operator can use the stylus to indicate where he wants any connecting bridges to be left. He then indicates the beginning cut point and direction of cut. The system then calculates the cutter path for all parts in the Nesting, leaving bridges of a previously defined width where ever indicated. At the bottom of the screen are shown three values

- Length of path in cutting mode,
- Length of path in positioning mode,
- Total machine tool time.

The Nesting may then be rearranged or the cutting order re-directed in order to give the optimum use of material and machine time.

Once the cutter center path for the completed nesting is calculated, displayed, and accepted, it is then passed back to the host computer for postprocessing by AUTOKON to produce numerical control tapes to machine the parts.


FUNCTION
MACHINE
PART DEFINITION
PARTS NESTING
CUTTER PATH CALCULATION
POST-PROCESSING
OUTPUT
MAIN COMPUTER (U-1100)
AUTOMATICALLY BY AUTOKON
VIA AUTOKON ROUTINES
-N/C CUTTER TAPES
-N/C PUNCH TAPES
ADAGE G3/300 GRAPHICS SYSTEM
GRAPHICALLY ON CRT
GRAPHICALLY ON CRT
AUTOMATIC WITH CRT MONITORING
MAIN COMPUTER STORAGE
PARTS
PARTS
NESTINGS
NESTINGS
G3/300 DISK STORAGE
PRINTER/PLOTTER ON-LINE TO G3/300
•DRAWINGS •LISTINGS
•DRAWING •LISTINGS
•DRAWINGS •LISTING
ADAGE INTERACTIVE DRAWING AND NESTING SYSTEM
FUNCTIONAL FLOW CHART

NESTING EXAMPLE (PRINTER - PLOTTER OUTPUT)

| | |
|---|---|
| Figures 1 - 5 | Previously defined parts (PART 1- PART 5) |
| Figures 6 - 7 | PART 1 and PART 3 called (in random position) onto sheet metal outline |
| Figure 8 | PART 3 repeated and reflected |
| Figure 9 - 11 | PART 2, PART 4, PART 5 called |
| Figure 12 - 13 | PART 3 positioned |
| Figure 14 | PART 2 and PART 5 - rough position |
| Figure 15 | PART 1 - rough position |
| Figure 16 | PART 5 - positioned, PART 4- rough positioned |
| Figure 17 | PART 2 and PART 4 positioned |
| Figure 18 | Bridge Defined |
| Figure 19 | Cutter Path Beginning (Zoomed) |
| Figure 20 - 22 | Cutter Path Continued |
| Figure 23 | Cutter Path Completed |

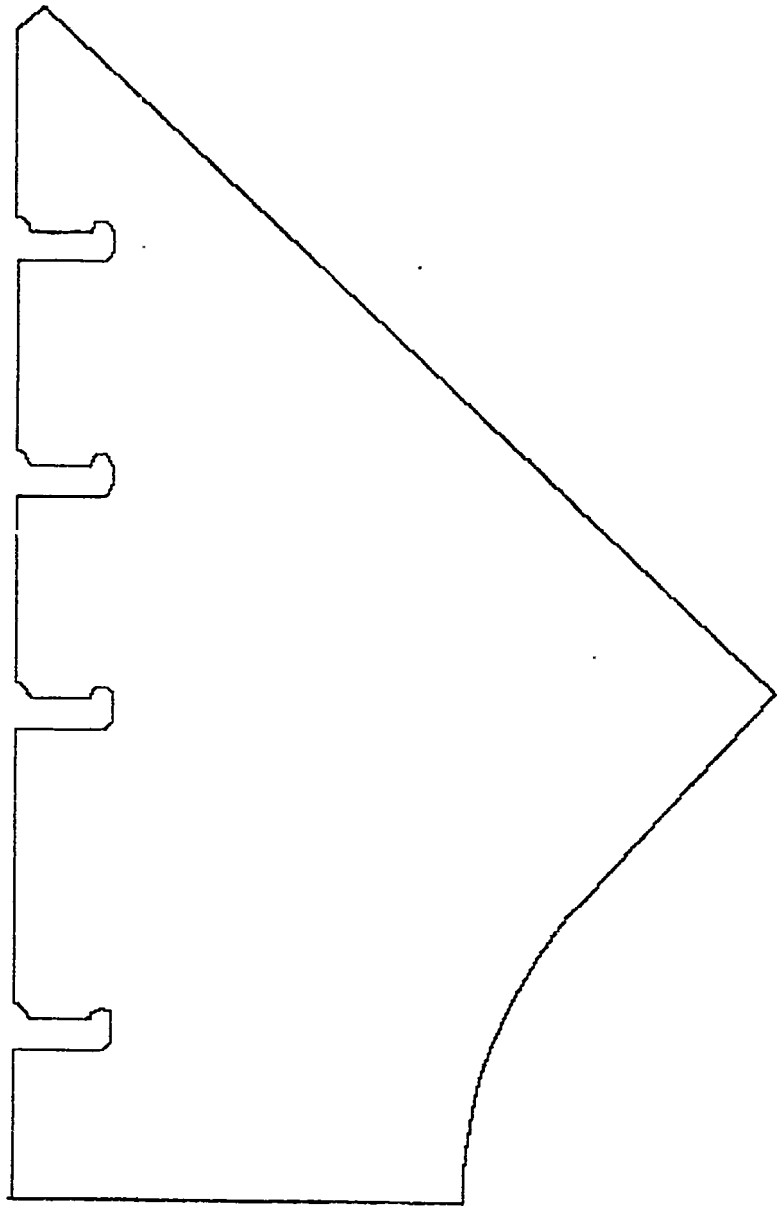


Figure - 1

PART 1

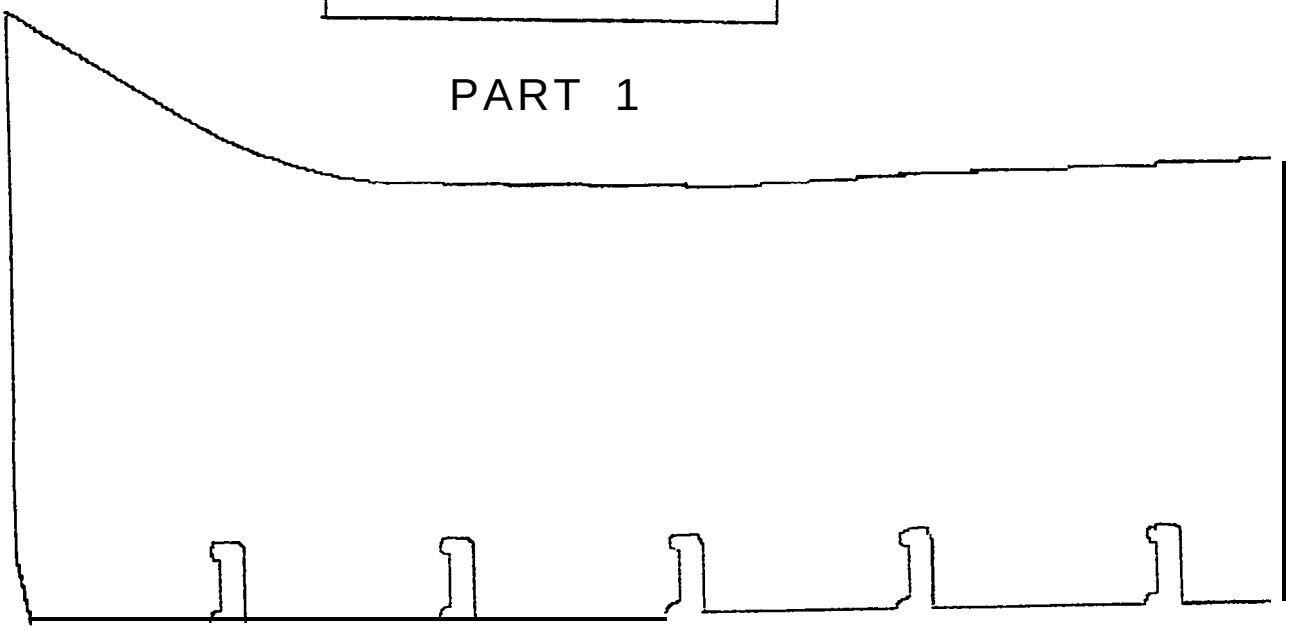


Figure - 2

PART 2

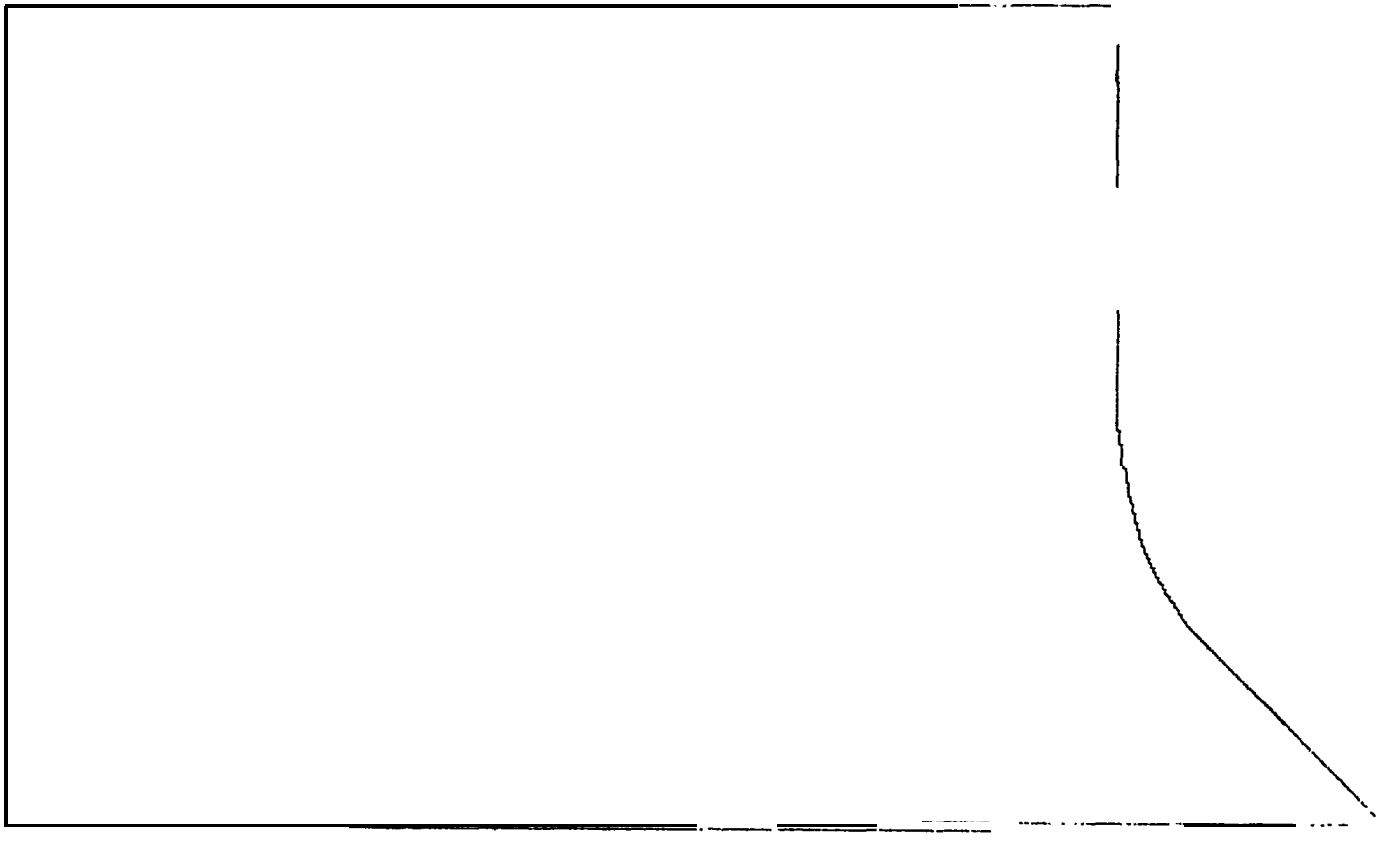


Figure - 3

PART3

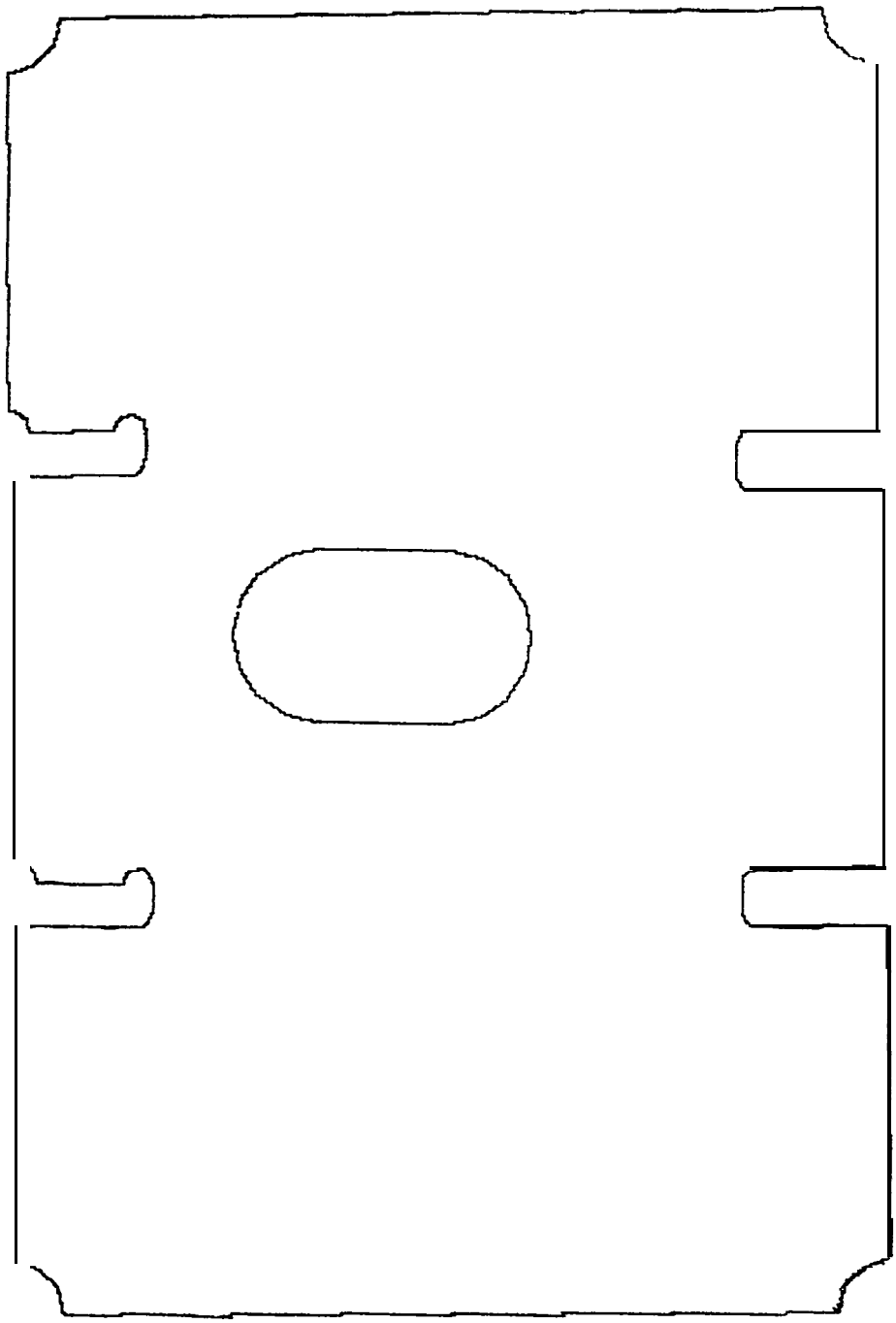
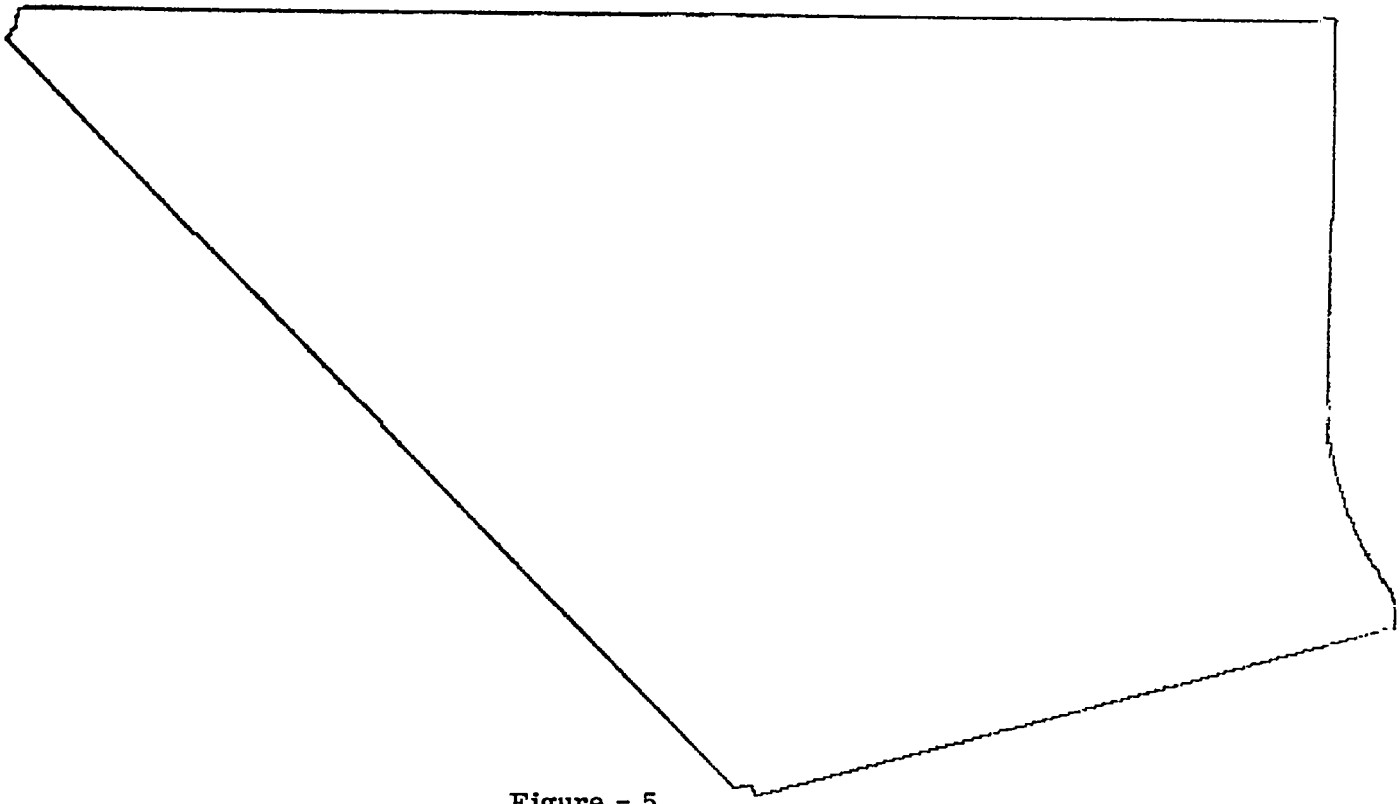



Figure - 4

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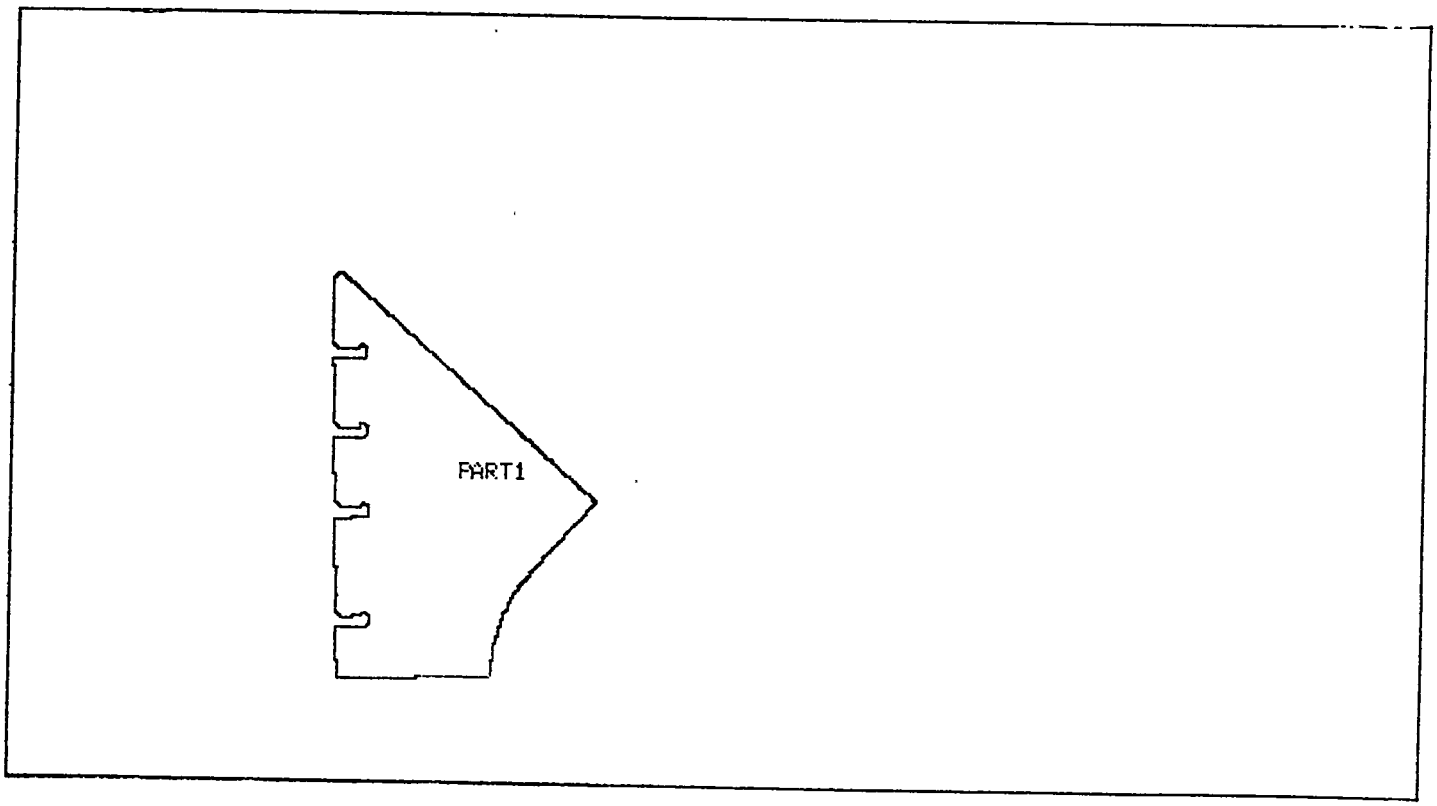


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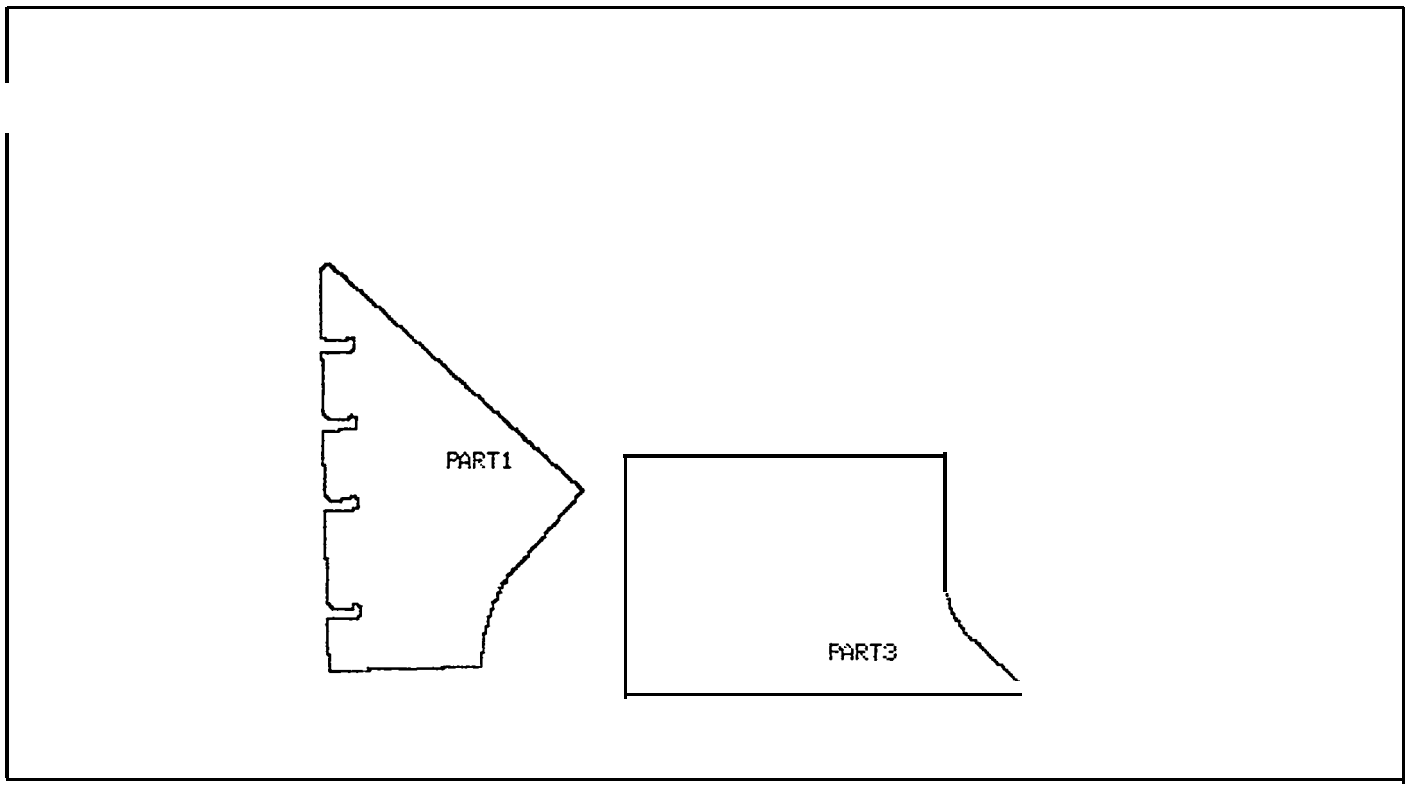



Figure - 7

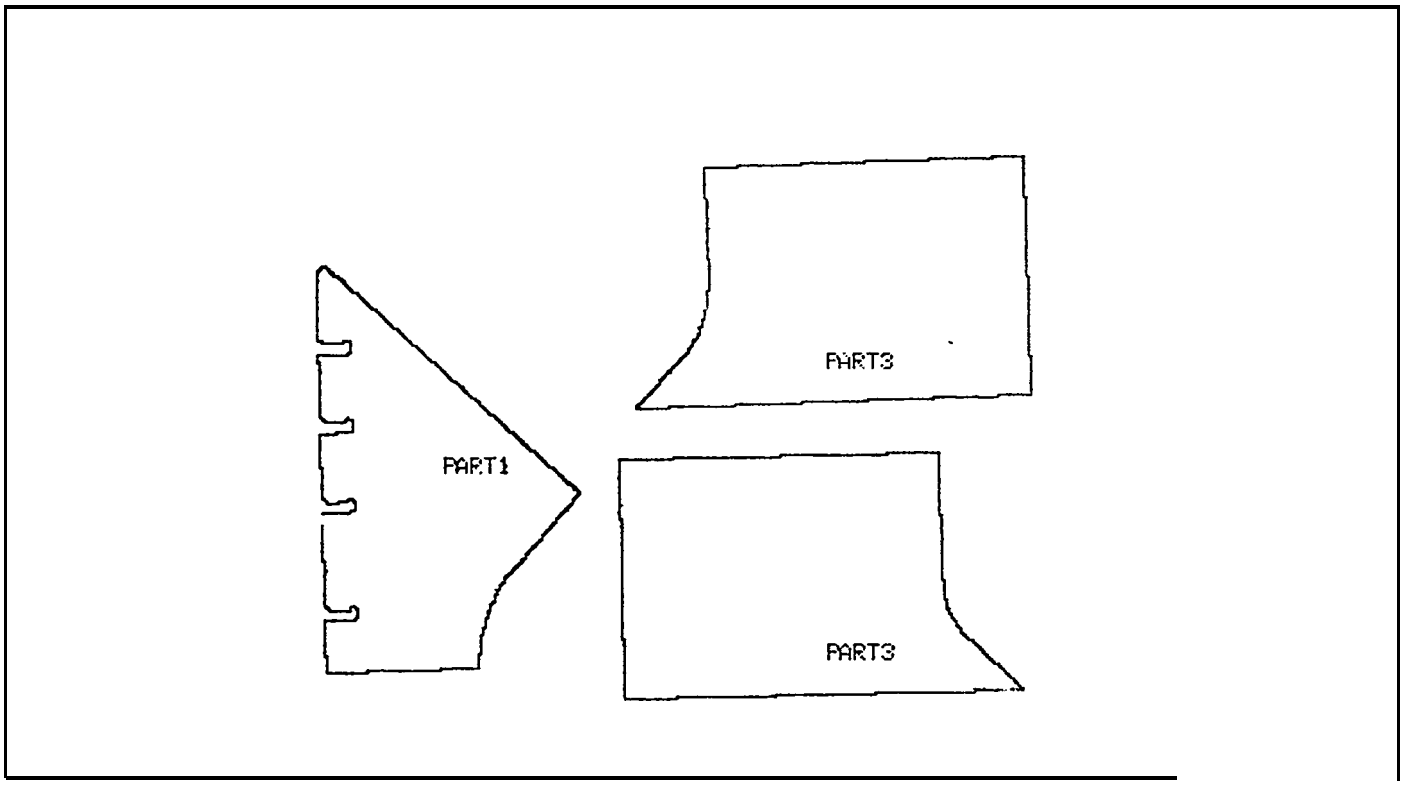



Figure - 8

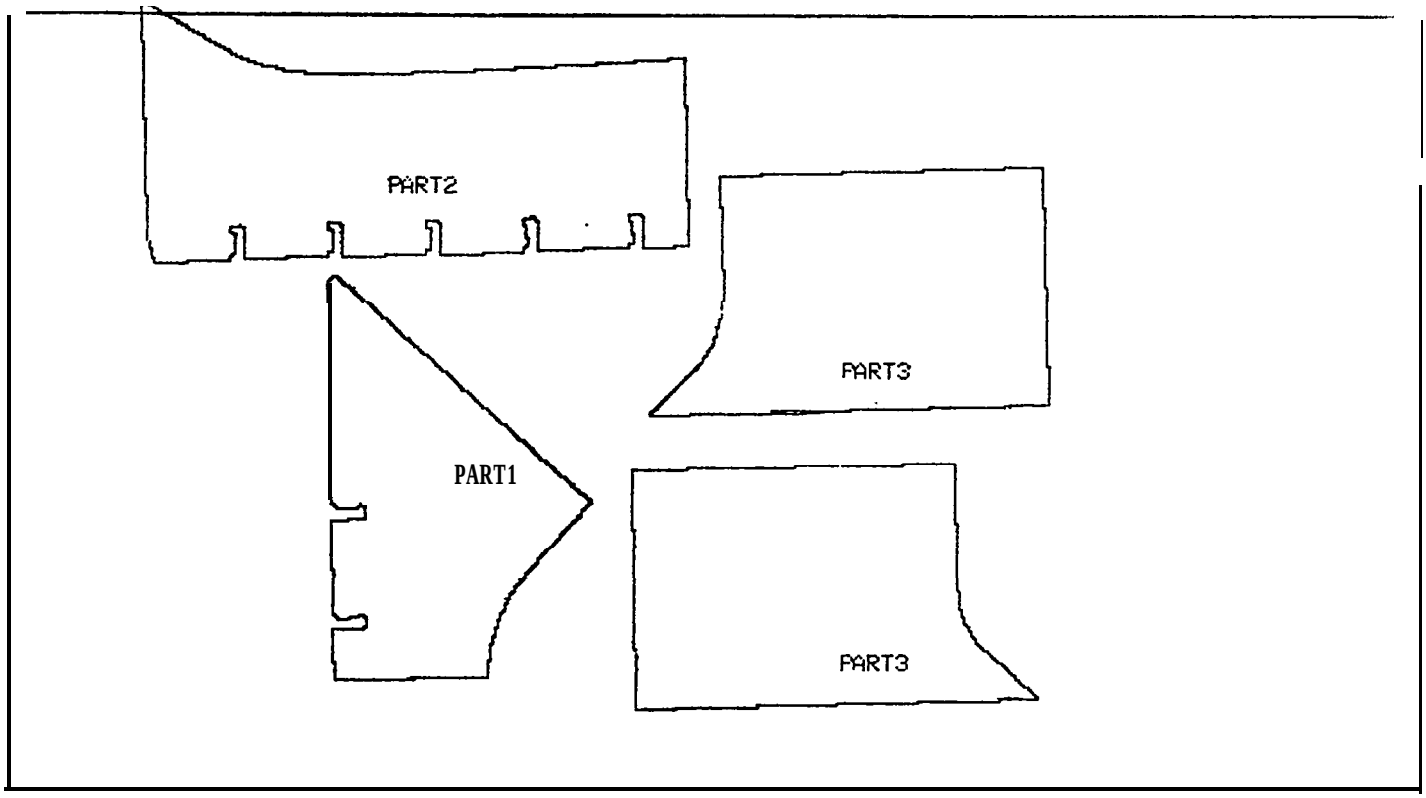
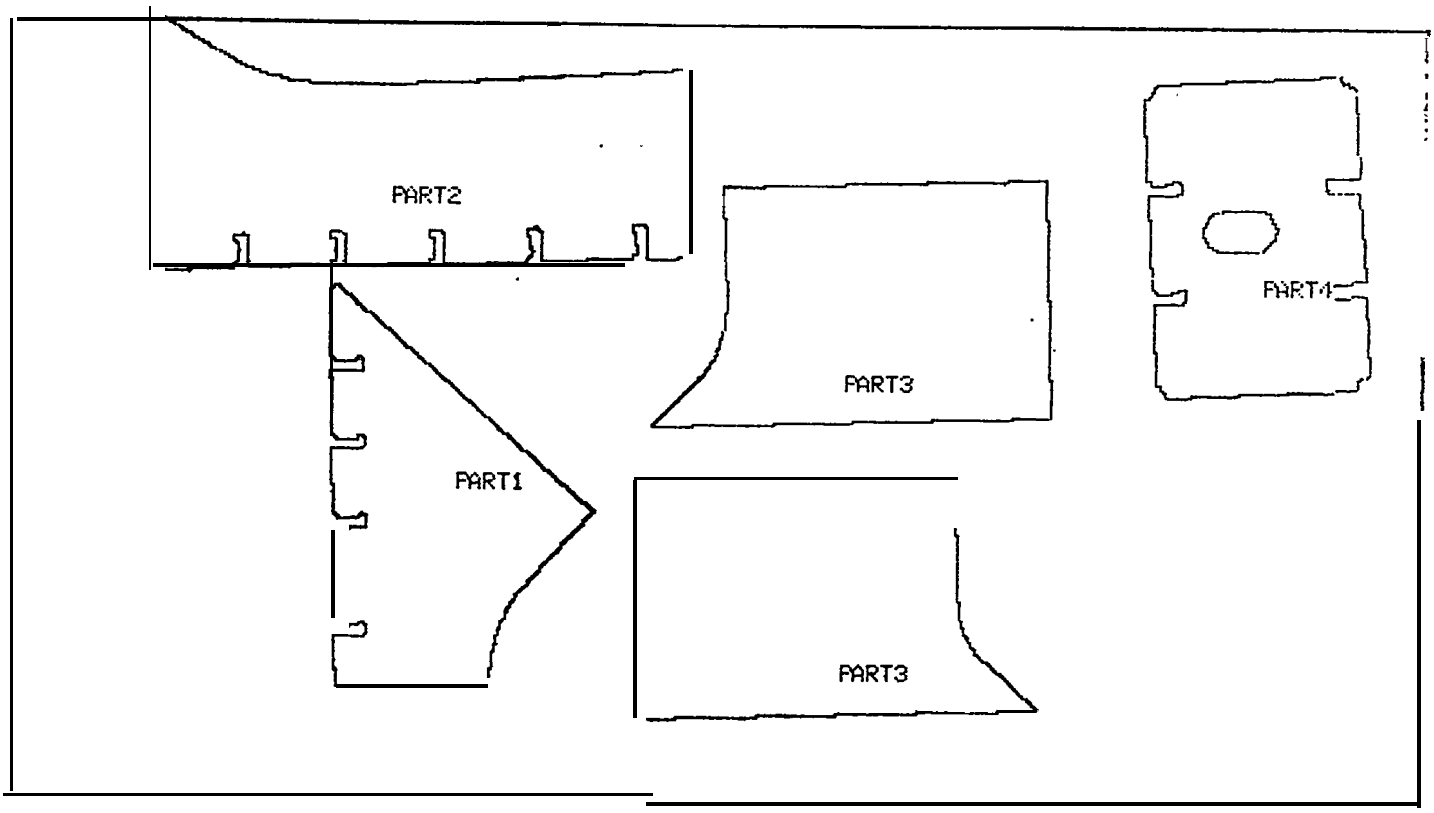



**Figure - 9**

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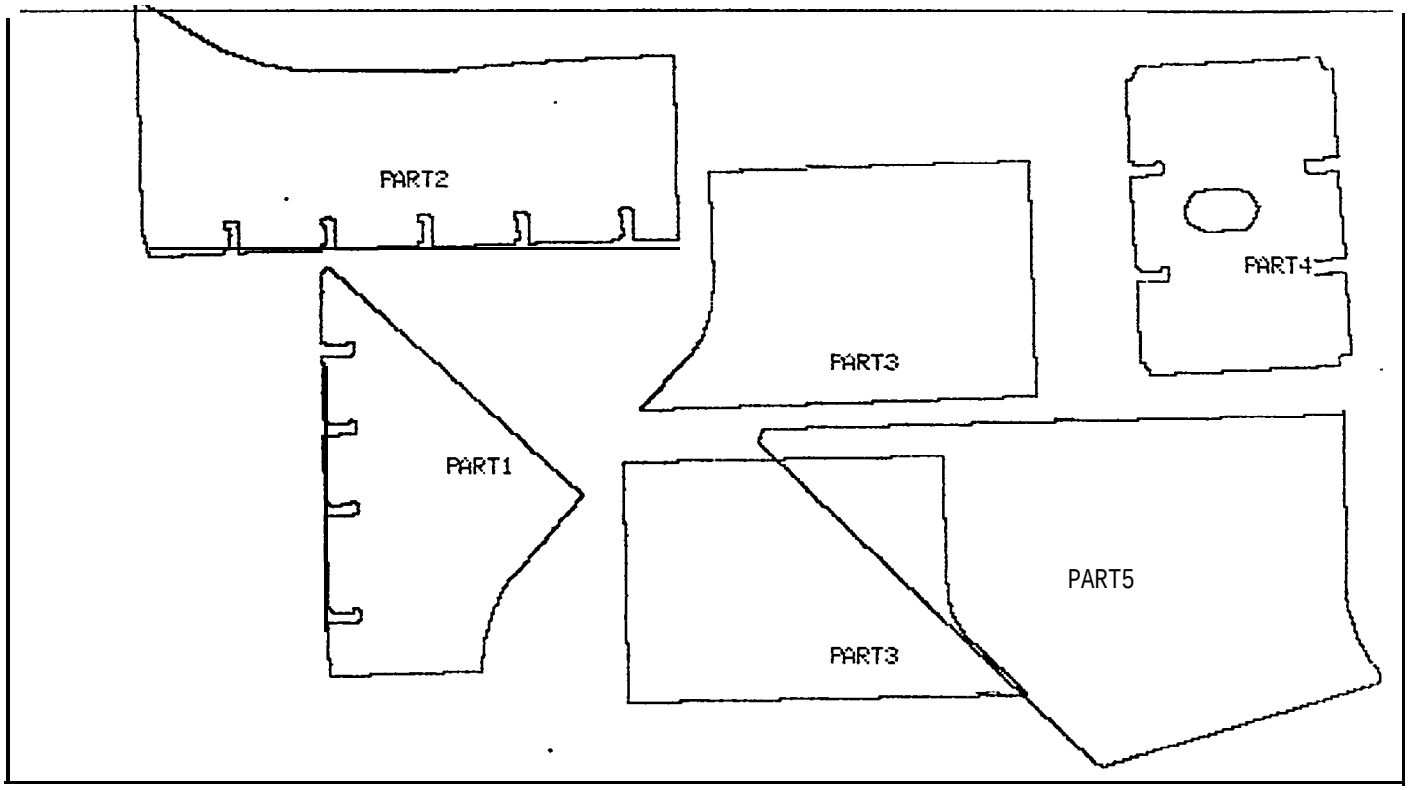
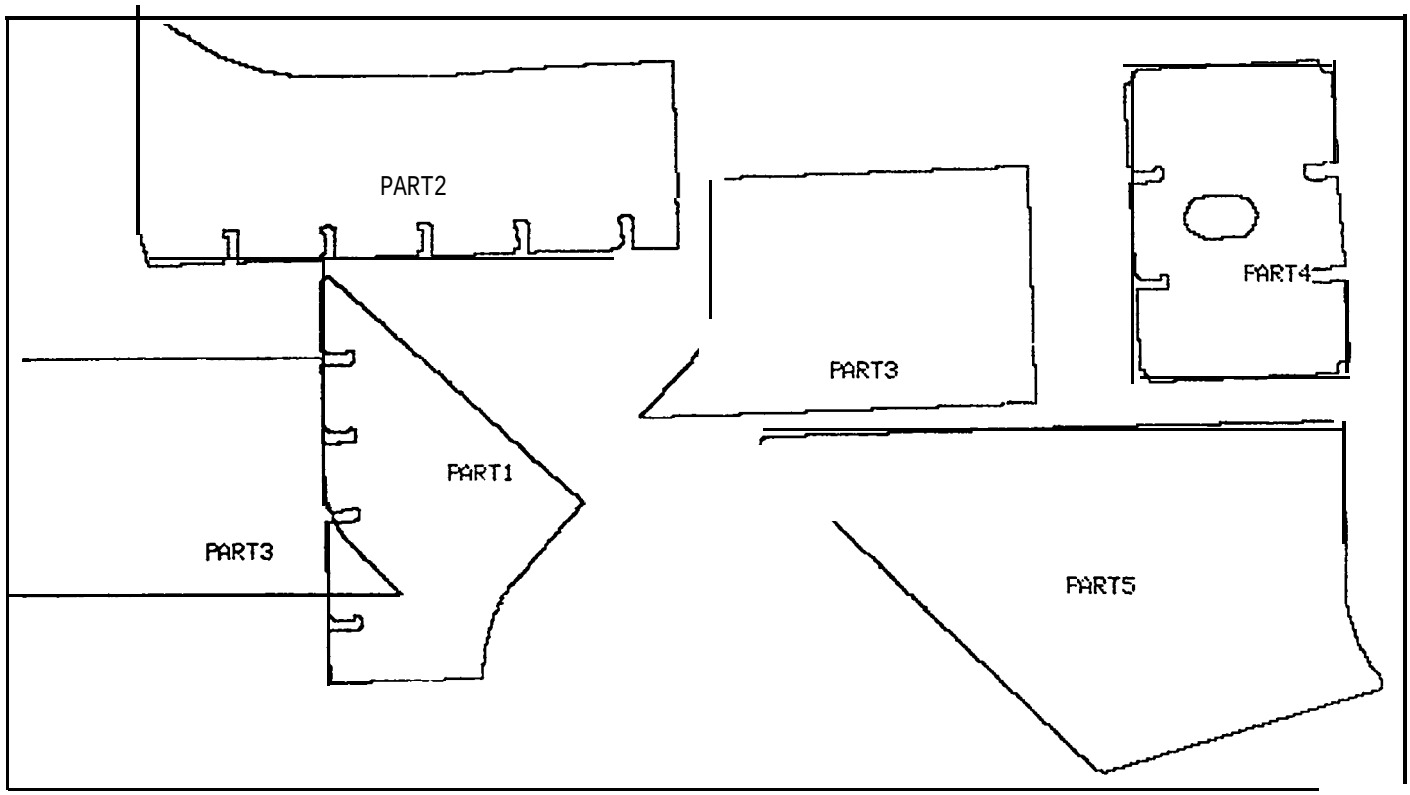



**Figure - 11**

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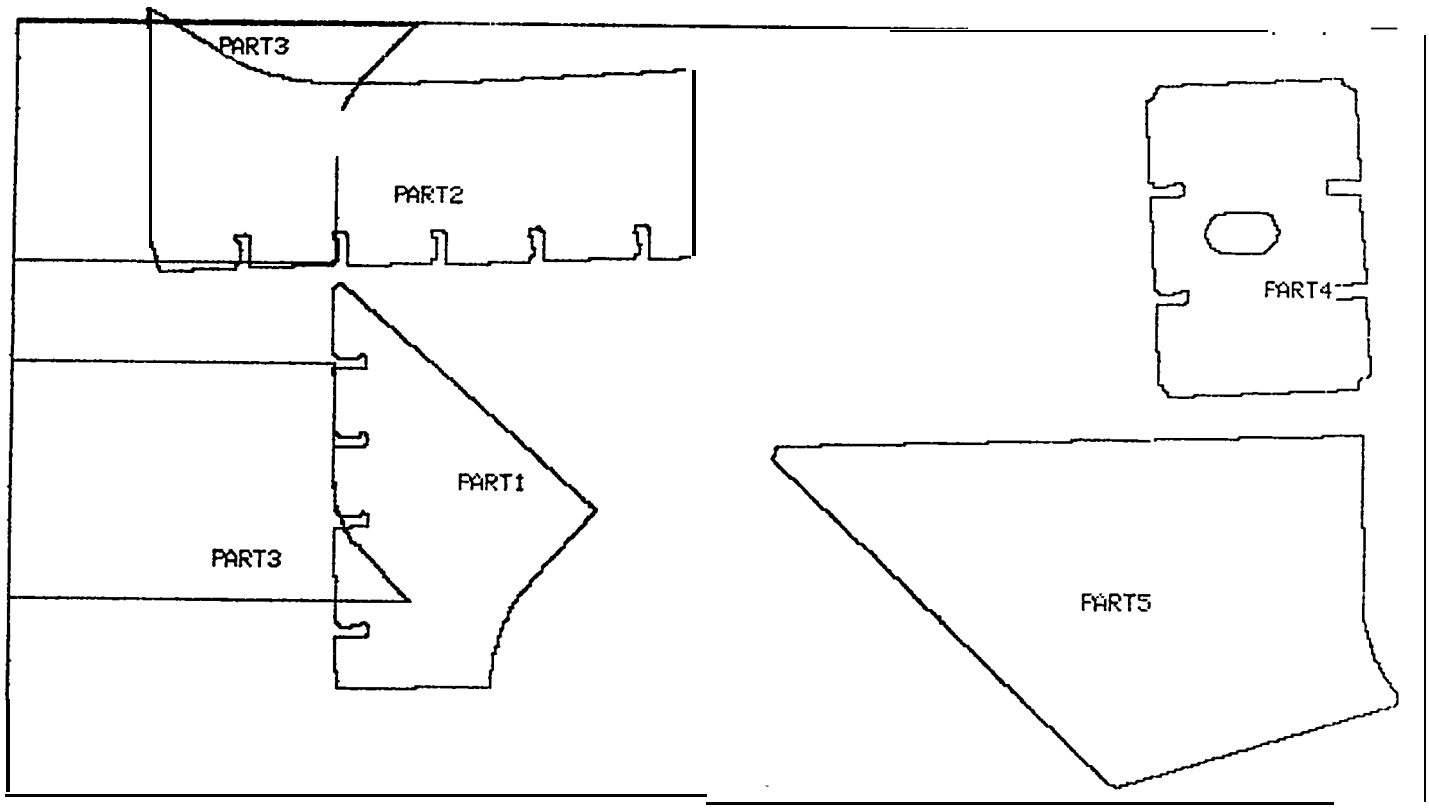
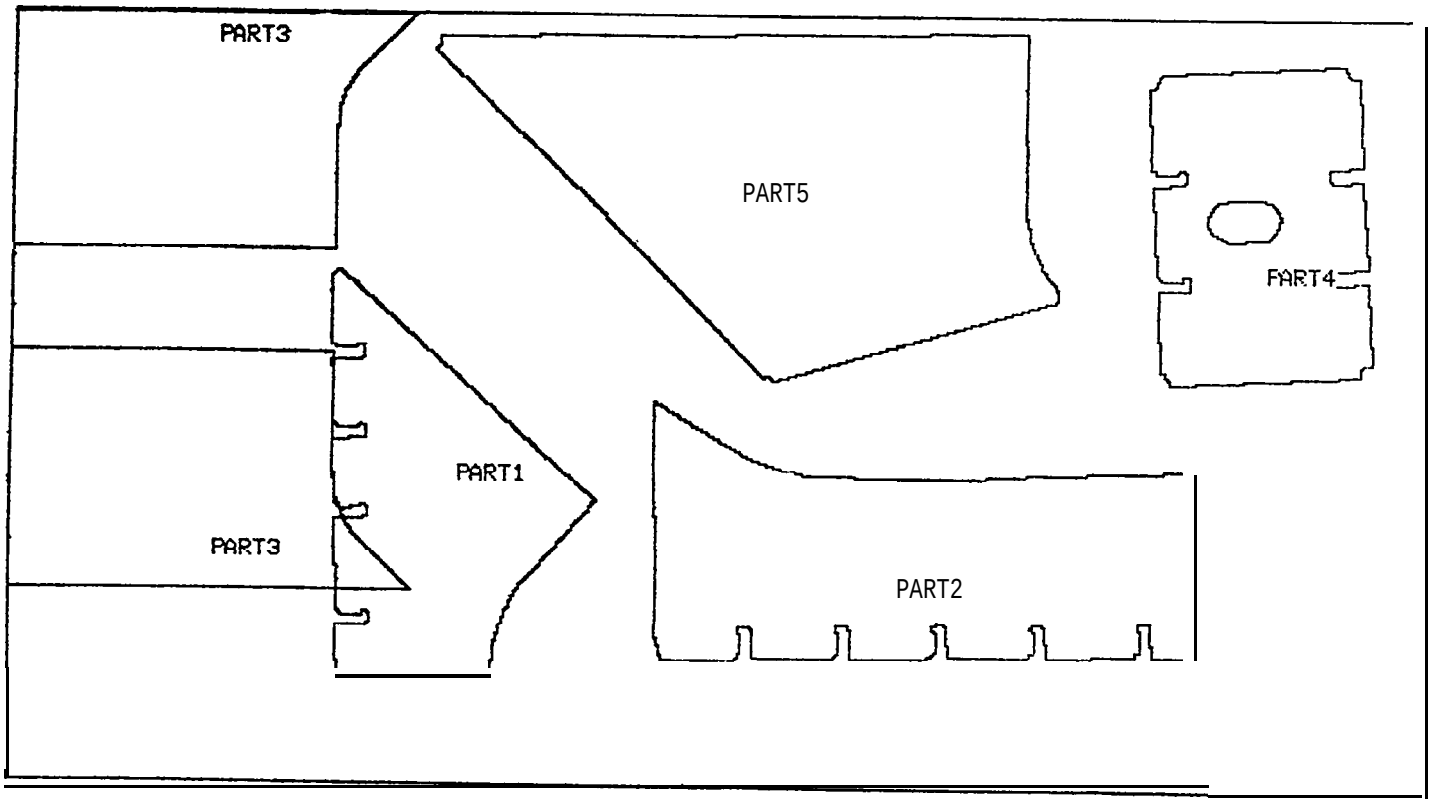



**Figure - 13**

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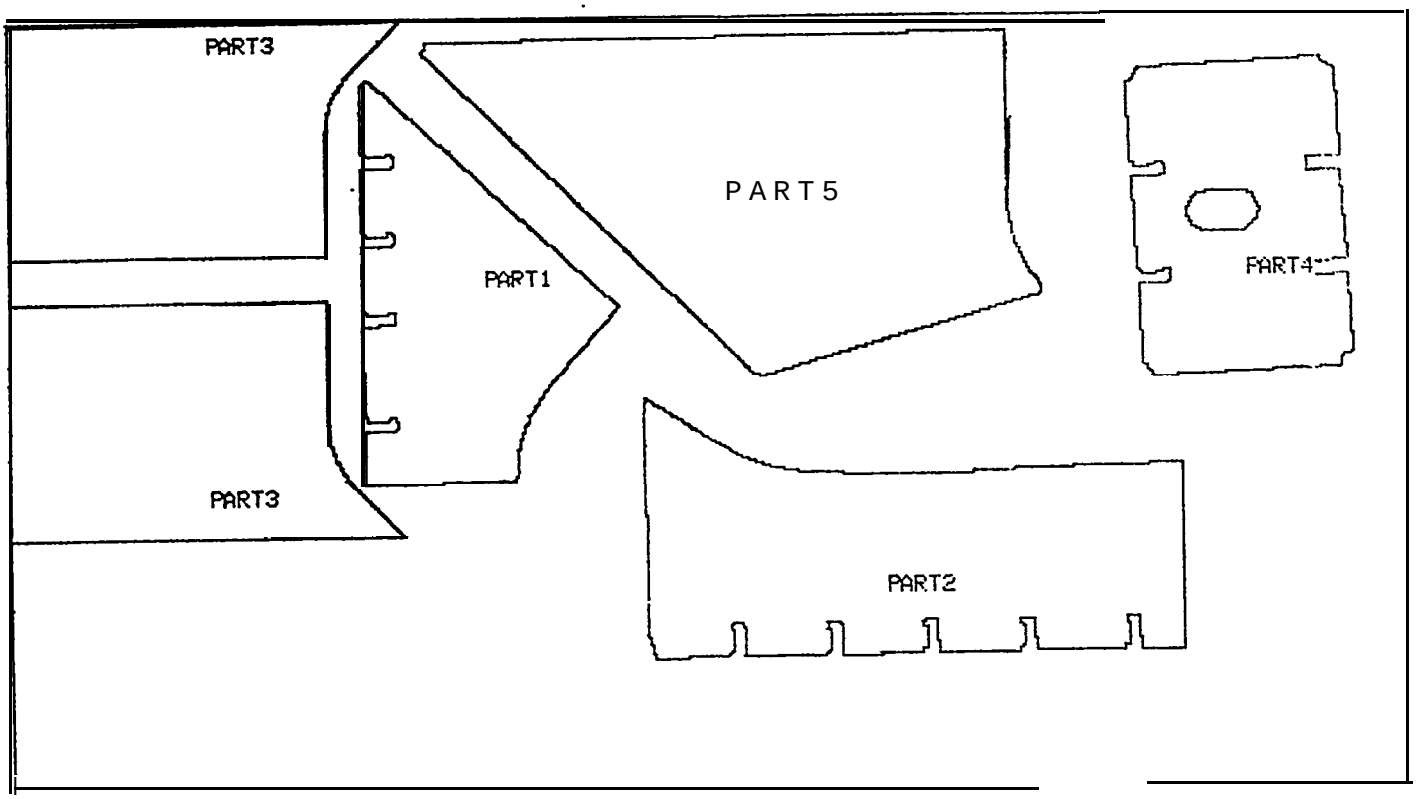
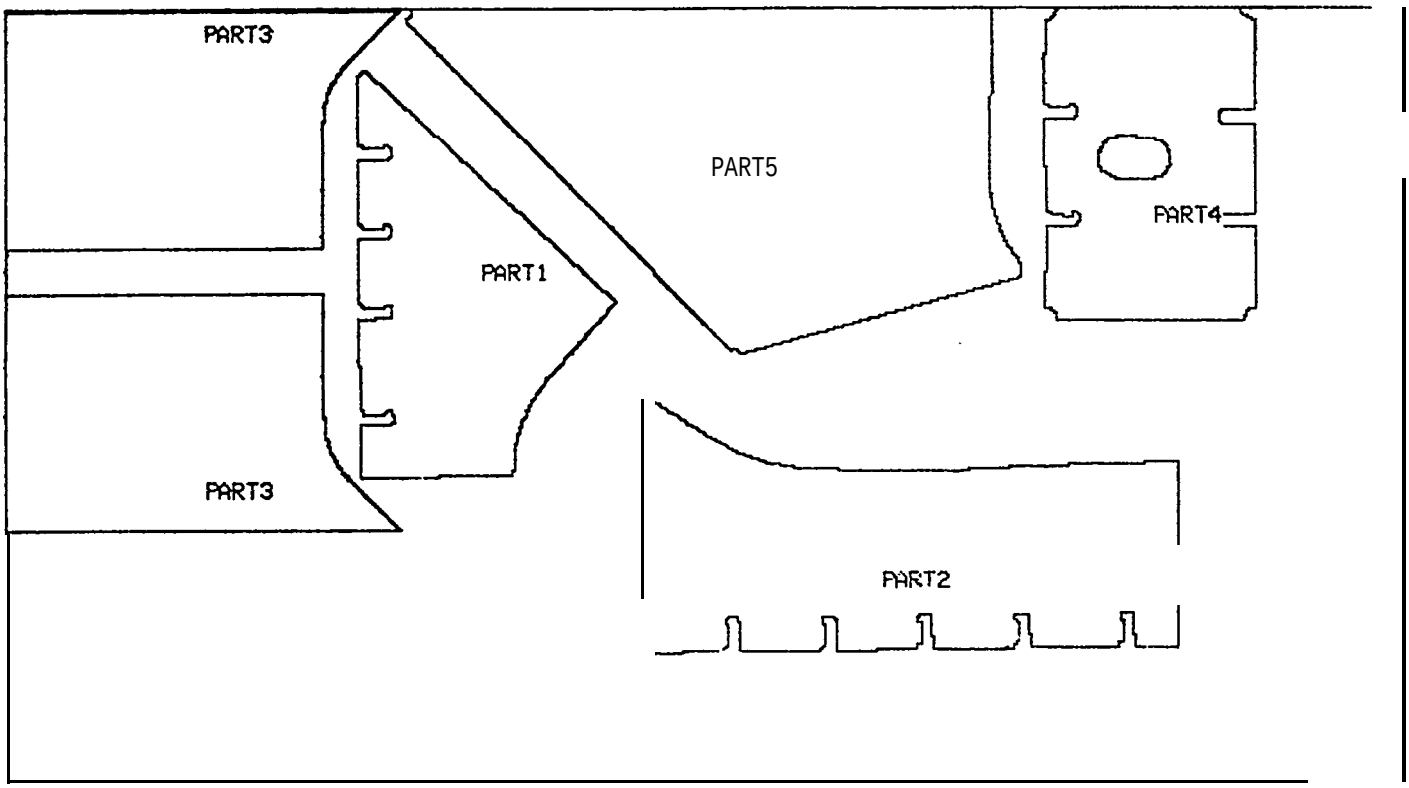



**Figure - 15**

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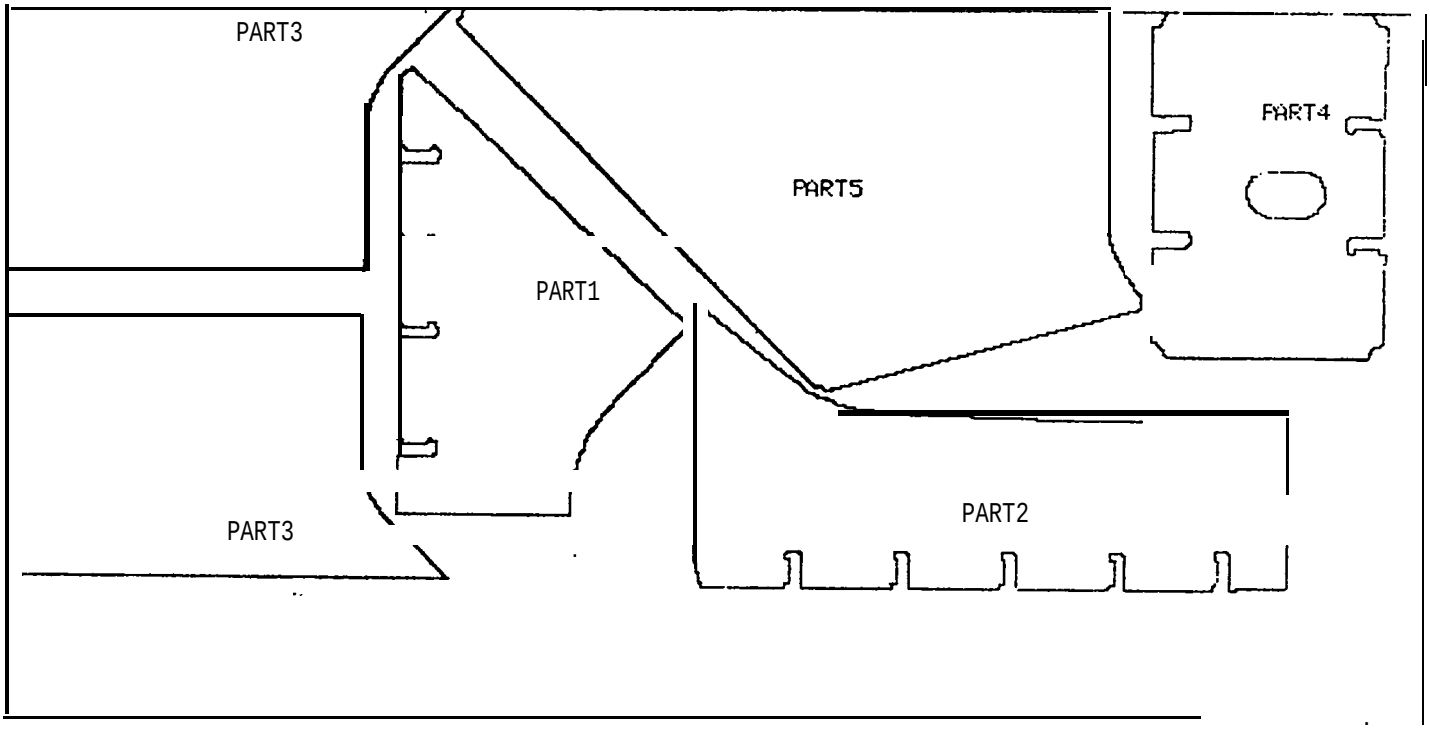


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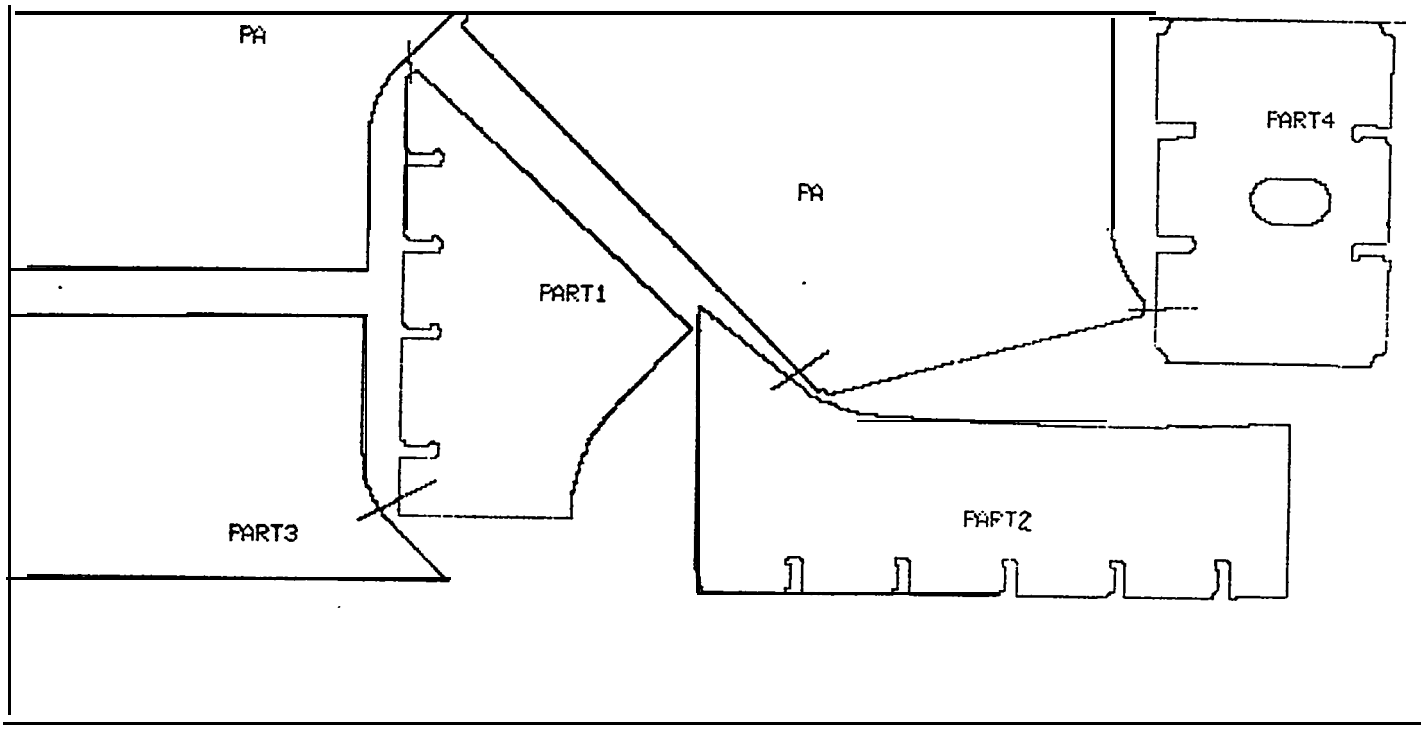
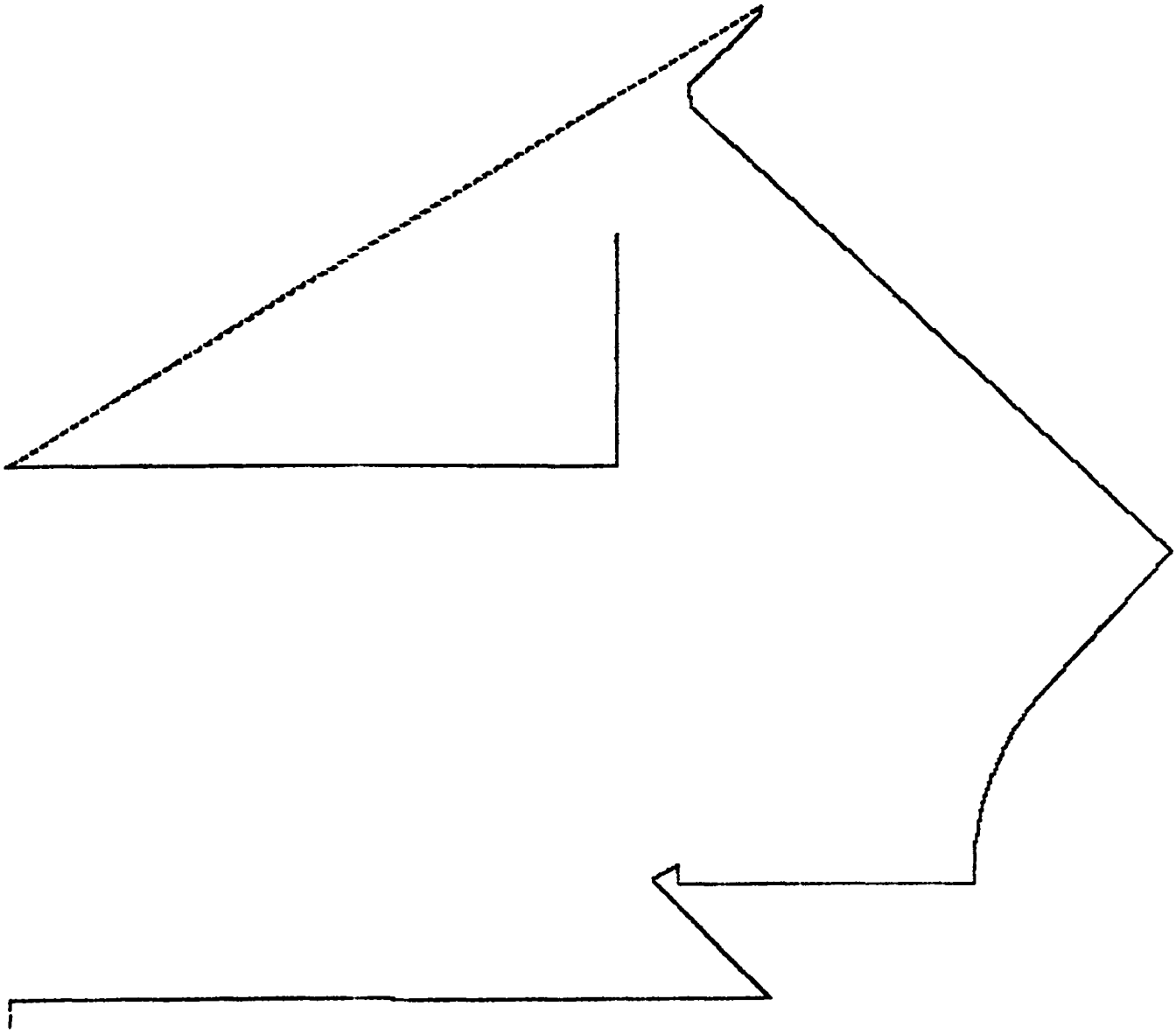


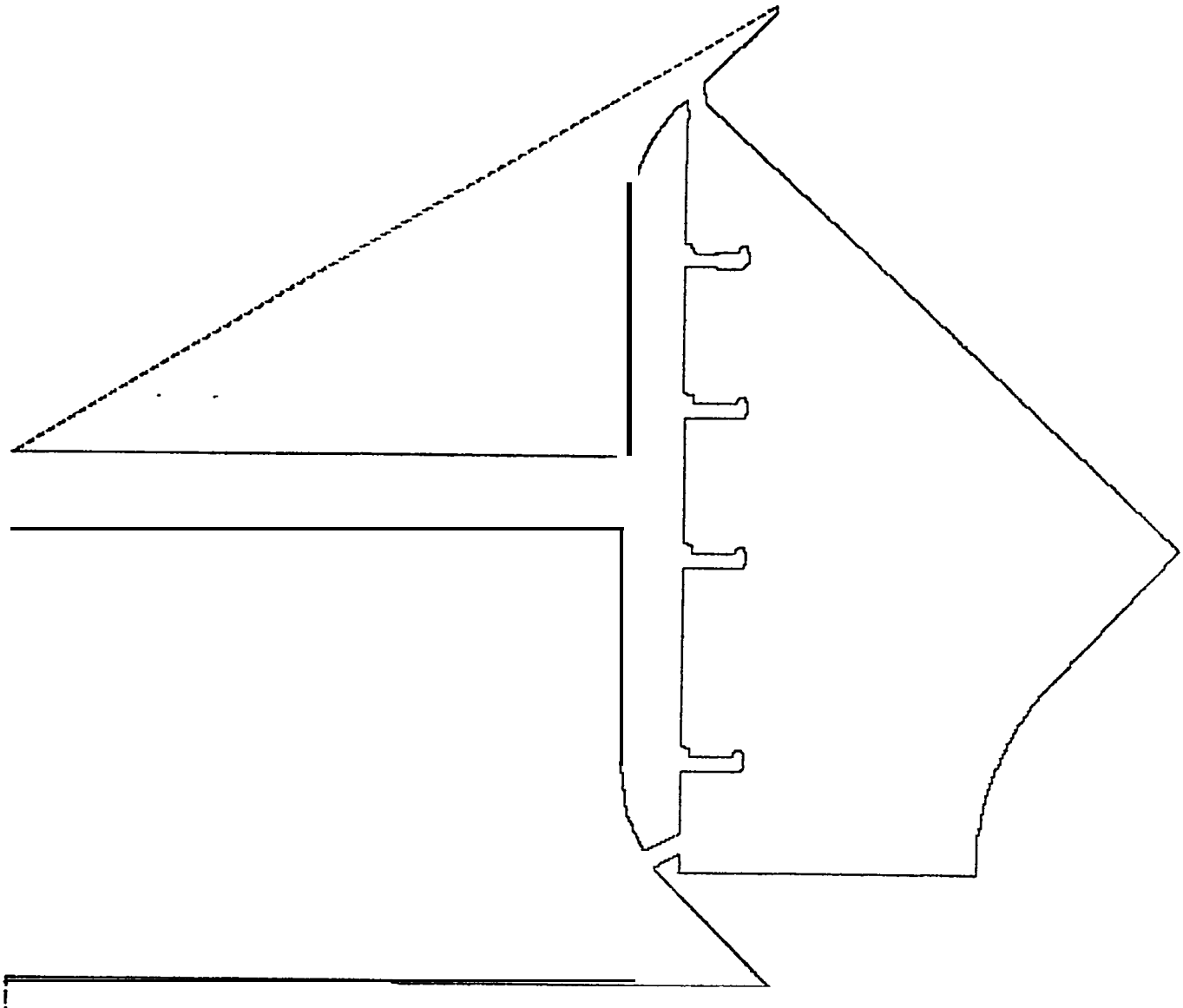

**Figure - 18**



Lunghazza del porcorso utensile in lavoro = 6789. (cutting length in mm. )

Lunghezza del percorso utensile alzato = 2313. (positioning length in mm. )

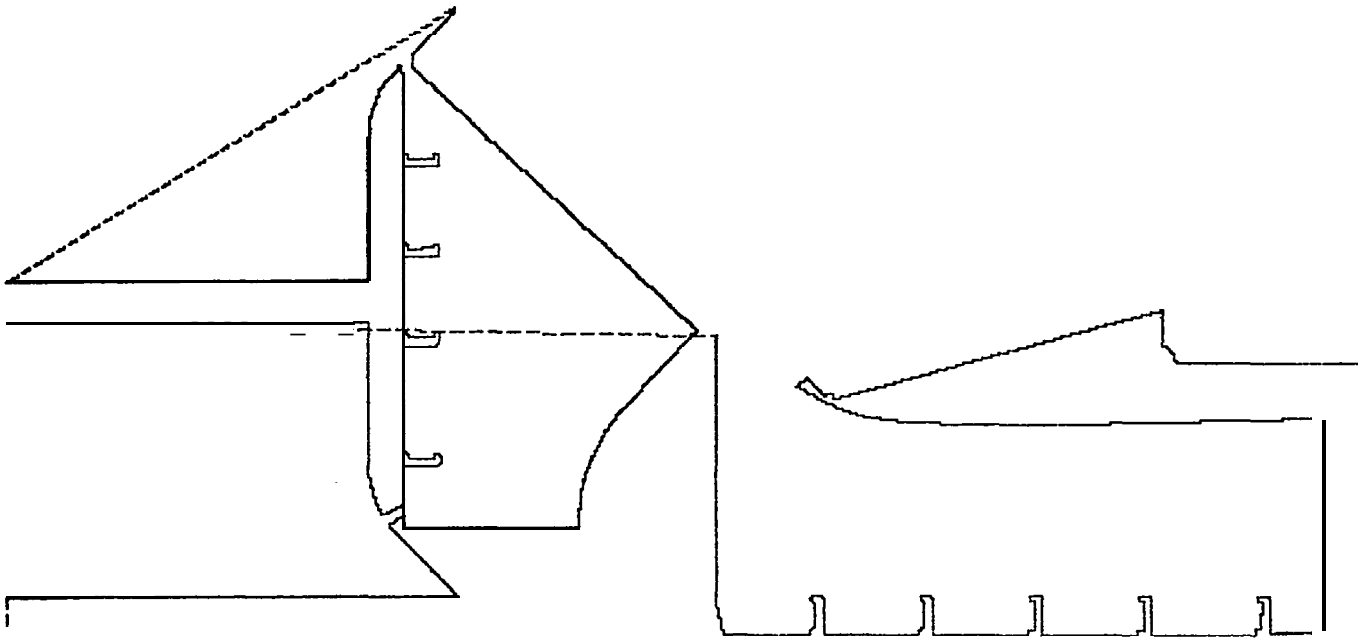
Figure - 19



Lunghezza del percorso utensile in lavoro = 11686.

Lunghezza del percorso utensile alzato = 2313.

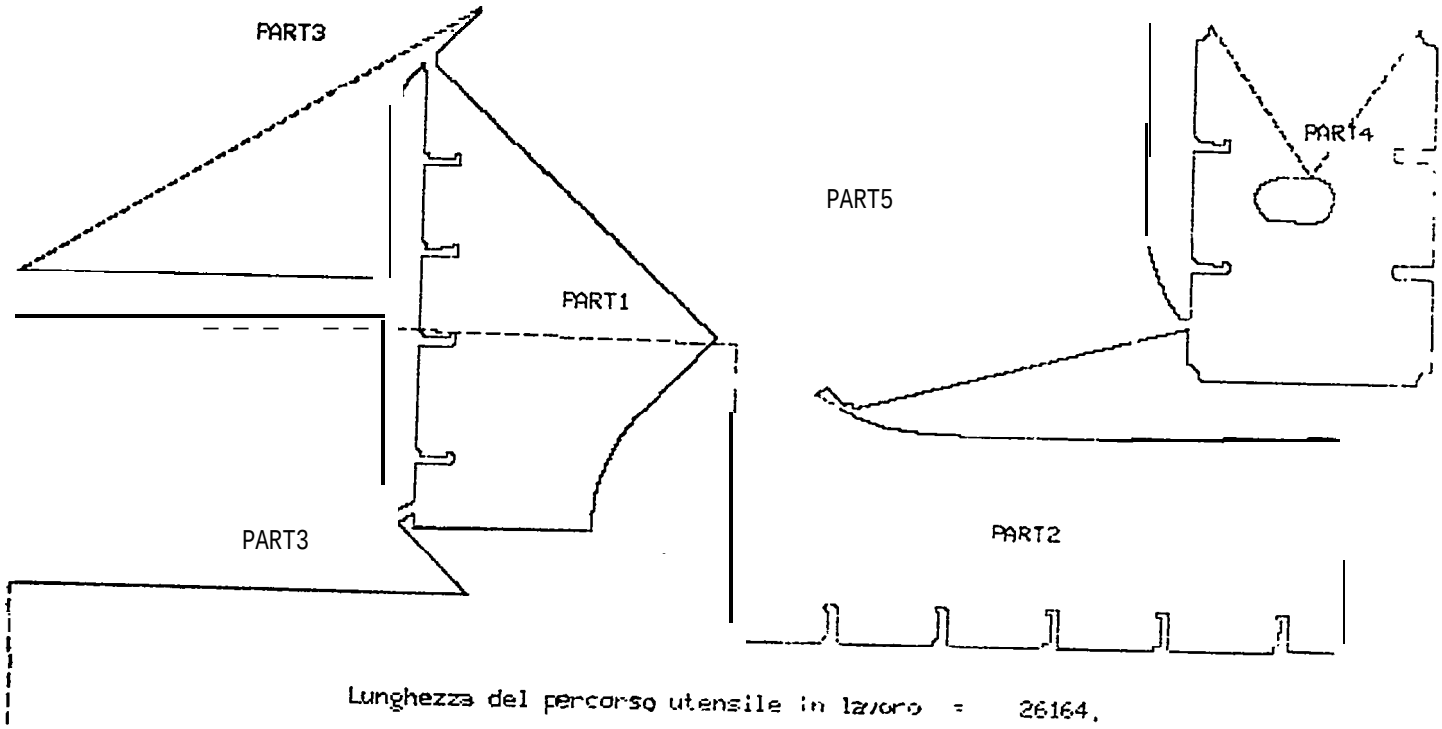
**Figure - 20**



Lunghezza del percorso utensile in lavoro = 21035.

Lunghezza del percorso utensile alzato = 4791,

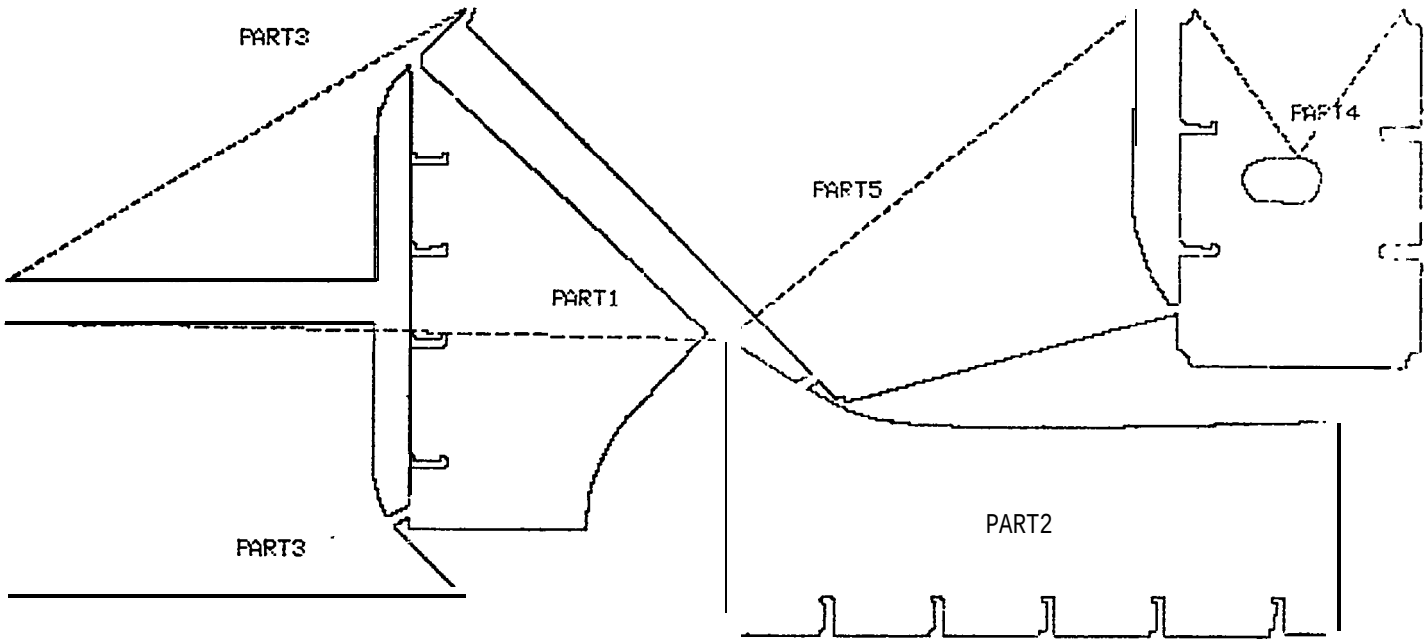
**Figure - 21**




Lunghezza del percorso utensile in lavoro = 26164.

Lunghezza del percorso utensile alzato = 6051.

**Figure - 22**




Lunghez a del percorso utensile in lavoro = 28264.

Lunghezza del percorso utensile alzato = 7858.

**Figure - 23**

THE ADAGE NESTING AND DRAWING SYSTEM
SOFTWARE PRODUCT SPECIFICATION
DESCRIPTION OF PROGRAMS

## I. Geometric Package

This portion of the system contains the routines which give the user the following capabilities: (1) to geometrically define those parts not defined by an automatic system (such as AUTOKON), (2) to take existing pre-defined parts and to divide them into smaller, more manageable parts, and (3) edit any previously defined parts, as necessary. Facilities are included which allow the user to set certain parameters or utilize certain functions which make it easy for him to conform to special design rules or fulfill the requirements of good nesting or machining practices.

A. The geometric functions include the ability to:

1. Draw straight lines
   - a. at any angle
   - b. at a constant angle
   - c 90° to last fixed vector
   - d. 180° to last fixed vector

2. Draw circular arcs
   - a. with a given radius, clockwise from end-point of last fixed vector
   - b. with a given radius, counter-clockwise from end-point of last fixed vector
   - c. with a given radius, tangent to last fixed vector at its end-point
   - d. through three points
   - e. described by given radius and an arc sweep generated by turning a variable control dial
   - f. by fillet at intersection of two vectors
   - constant fillet at subsequent vector intersections
   - h. inside fillet or bead at intersection of two vectors
   - i. constant inner fillet

3. Draw circles
   - a. with arcs' definitions a. through e. above
   - b. with given center point and radius
   - c. concentrically with variable radius about fixed center point

4. Draw eyelets by defining center and radius of major arc and center and radius of minor arc

5. Call out ESSI arc parameters for any arc

6. Draw new part geometry, parallel to old at given offset

7. Draw with perspective projection of a particular contour

8. Selective erase of any line or curve

9. Menu items, which can be any series of geometric definitions grouped together as an entity, such as slots for longitudinal members, which are then available to be displayed at the bottom of the screen to be selected and placed repetitively on the part being designed, in whatever orientation or scale is desired.

## II. Nesting Package

These routines give the user the ability to work from the display console and call lists of previously defined parts to be displayed on the screen, arrange these parts into nests, store and retrieve completed or partially completed nests, edit any nest or parts within a nest, pass auxiliary operation or set-up information to machine tool operator, and to pass cutter-path information back to the host computer for post-processing to produce punched tapes for numerically controlled machine tools.

A. TRAPART: Transfer parts to be nested from the host computer to the ADAGE GS/340

1. Uses IDN (Identification No. ) to find parts reque steal;

2. Searches AUTOKON data base for ESSI parameter list for each IDN;

3. Calculates the area and center of gravity for each part;

4. Creates a data file for transmission;

5. Transmits data to the ADAGE GS/340 to be stored on disc.

B. NESTING: Performs data manipulation, part set-up and nesting, cutter path definition, and partial post-processing.

1. Data manipulation includes

   a. copying of parts at same or different coordinate transformations or reflections
   b. insertion of new parts or parts from different files deletion of parts
   d. data compression and reduction

In particular, this part of the program allocates the required work files to the user and prepares the interim or final results to be transferred to the host computer.

2. Parts Set-up Operations include:

   a. Display parts, one at a time, now stored on Adage disc files
   b. Transformation of a part or set of parts in X and Y and rotation around center of gravity or any selected point
   c. Preliminary grouping of parts into a set of parts
   d. Reflection of a part or set of parts
   e. Placing or deleting a part or set of parts on sheet metal outline
   f. Duplication of a part or set of parts
   g. Setting parameters for interference distances and parallel distances
   h. Replacement of positioned parts with similar parts
   i. Definition or re-definition of sheet metal outline dimensions
   j. Calculation of overall efficiency and percent of waste
   k. Display of stacked sheets of metal (up to eight) so that a particular nesting area is carried through to each sheet.
   L Definition of any preliminary cuts
   m. Storage and retrieval of general or non-cutting information for each part
   n. Output of auxiliary operational information such as, arrangement of metal plates in fixture, number of cuts, description, etc.
   o. Hard copy output of a detail part or of entire cutting path as well as auxiliary information on each sheet or parts
   p. Storage of partial or final results on ADAGE GS/300 disc files
   q. Retrieval of stored partial or final results for completion or modification

3. Nesting Completion - Utilizes parts position data to perform the following functions:

   a. Retrieval from the ADAGE disc files of a nesting to be completed or of a completed nesting to be modified
   b. Calculation or initial positioning moves
   c. Calculation of any excess metal to be left on periphery of any part.
   d. Calculation of scribing path
   Examination and modification of cutter path
   f. Definition of connecting bridges between individual parts
   g. Insertion of auxiliary and miscellaneous function codes and comments

h. Calculation of compensation for width of cutter path
i. Provision for eyelets as starting holes for cutting torch adjustment for bevel cuts
j. Redefinition of the cutter start point on the circumference of the part, due to machining requirements
k. Modifications required to cut different sizes of metal parts
l. Automatic summations of cutter path length for both rapid traverse (positioning) mode and for metal removal mode
m. Display of all paths
n. Measurement and summation of cutter path length for sections to be cut by semiautomatic system
o. Display of dimensional measurements for verification purposes
p. Storage on Adage disk files of final or partial results

C. STONEST: Restructures and stores interim and final nesting results on host computer files; functions include:

1. Translation of incoming data from Adage system
2. Restructuring or identification data to give
   -file name
   -record type
   -record name
3. Storage of final data for each cutter path

D. TRANEST: Transfers to Adage system the data required to complete the cutter path, including the following functions:

1. Reading a deck of cards to determine list of items required for transfer
2. Retrieving from host computer data base the interim or final results required
3. Retrieval of required parts from AUTOKON data files
4. Transformation of data and arrangement for transmission
5. Transmission of data to an Adage disk file

E. USEDATA: Utility routines in host computer for:

1. File modification
2. File compression
3. Preparation and editing of punched tape for numerical control machine tools (completion of post-processing).